

Governance and Guidelines

Best Practices in Dam and Levee Safety Risk Analysis

Part A – Risk Analysis Basics

Chapter A-9

Last modified June 2017, presented July 2018



US Army Corps
of Engineers®



Outline

- Objectives and Key Concepts
- Background and History
- Terminology and Framework
- Guidelines
- Urgency
- Examples



Objectives and Key Concepts – Governance and Guidelines

Objectives

- Provide historic context for tolerability of risk concepts
- Define tolerable risk guidelines for dam and levee safety

Key Concepts

- Dam and levee risk vs. flood risk
- Tolerable risk
- Individual risk
- Societal risk

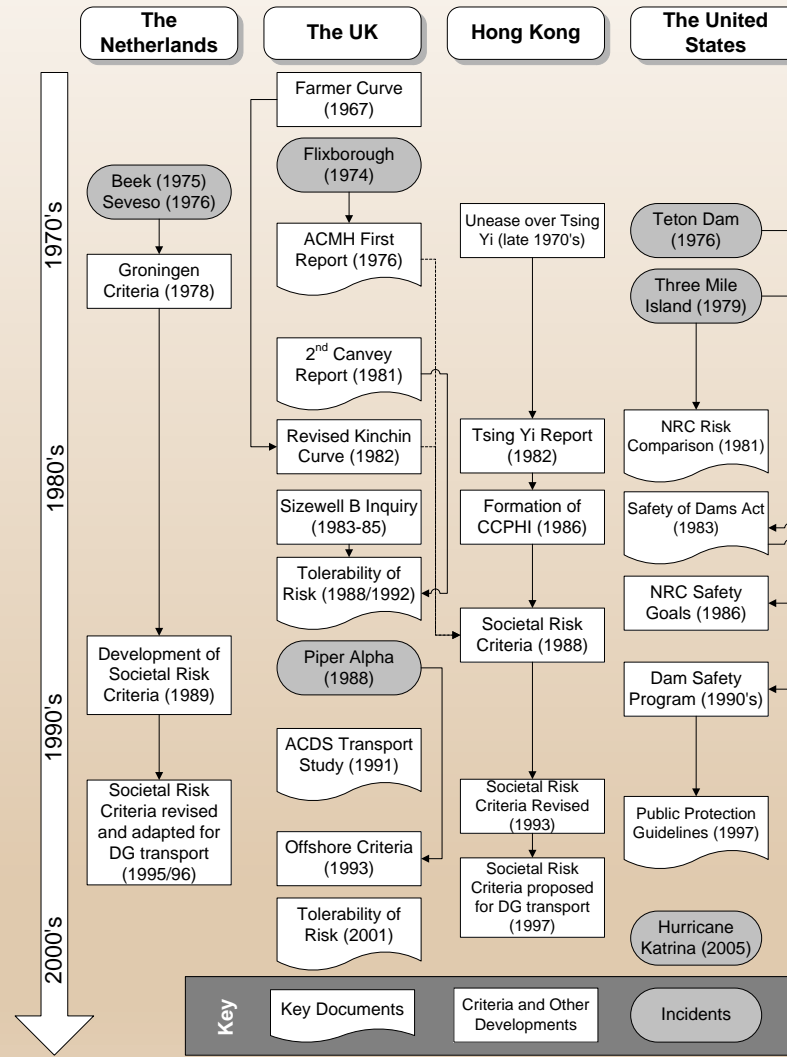


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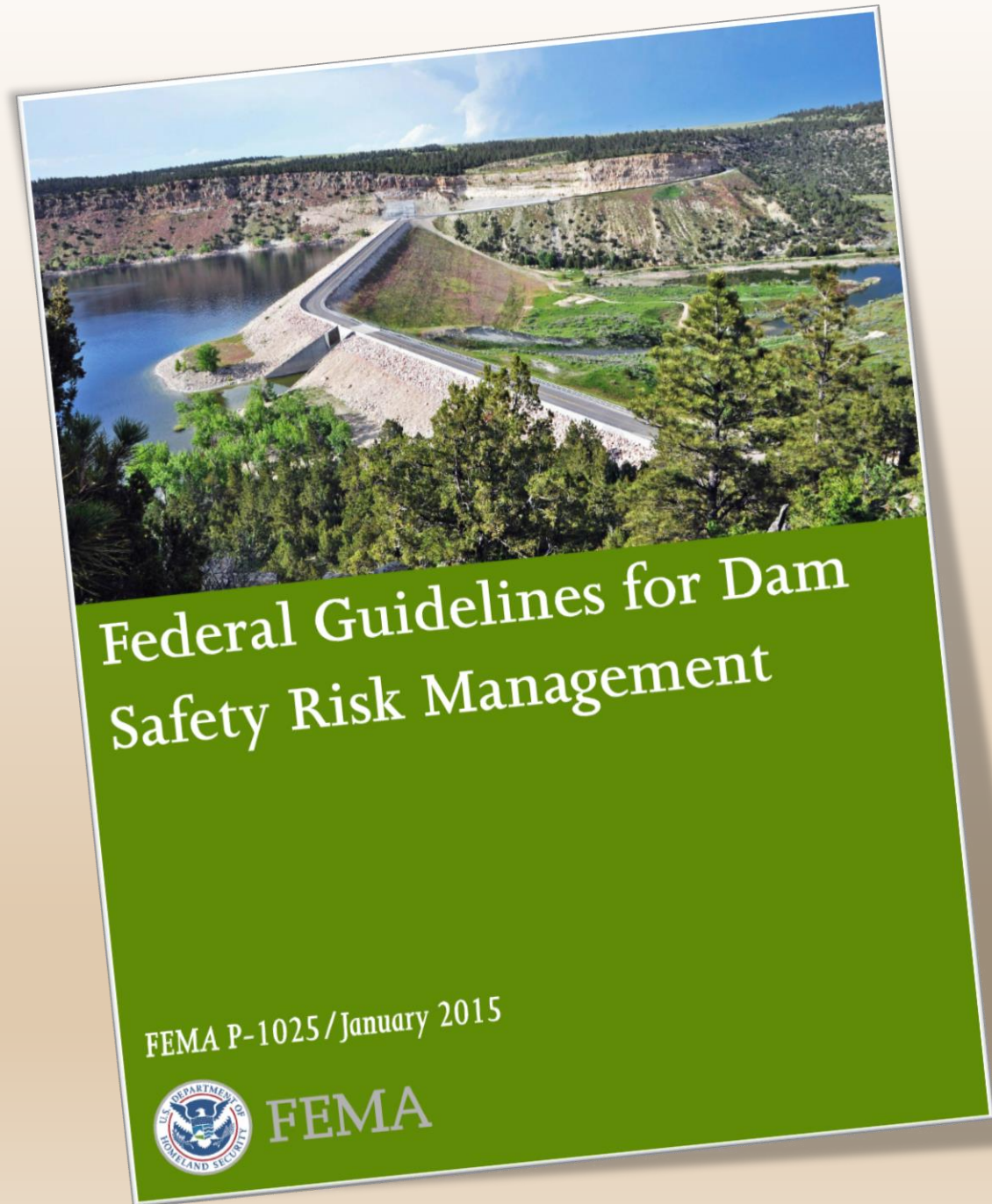
Background

- Lineage
 - UK Atomic Energy
 - UK HSE
 - Australian
 - Dutch
 - US Data
 - Reclamation
- Federal Guidelines
 - USBR PPG
 - USACE Dam and Levee Safety
 - FERC Draft
 - TVA Draft
 - FEMA Federal Risk Management Guidelines

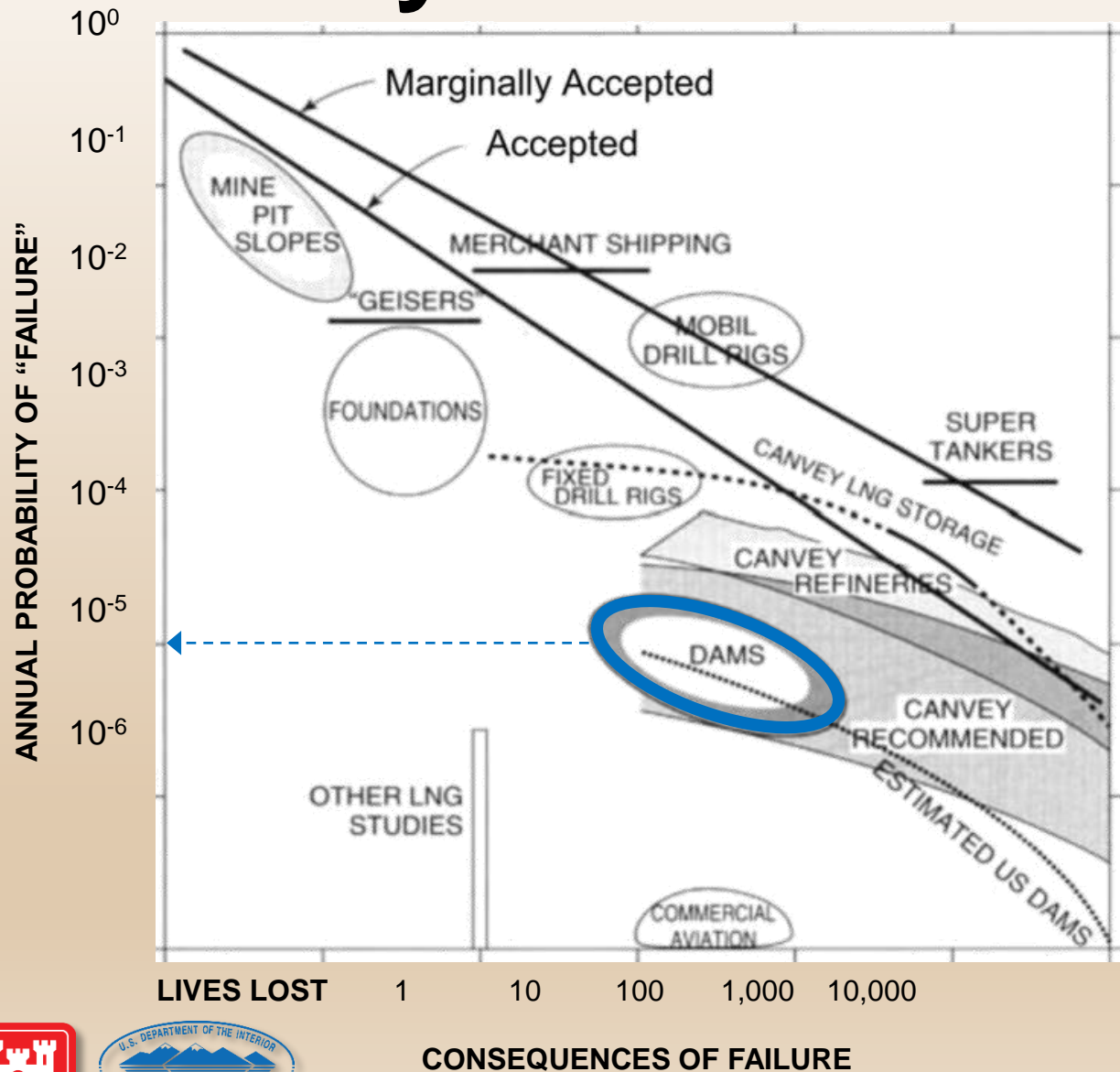


Federal Guidelines – Objectives and Guiding Principles

- Life Safety is Paramount
- Risk should inform the decision process and improve the status of safety related to dams
- Identify and reduce the risk to life and property posed by dams and reduce those risk to as low as reasonably practicable
- Each agency has a unique authority, mission, and management practice – their use of risk to inform decisions may vary
- The urgency of completing dam safety actions should be commensurate with the level of risk



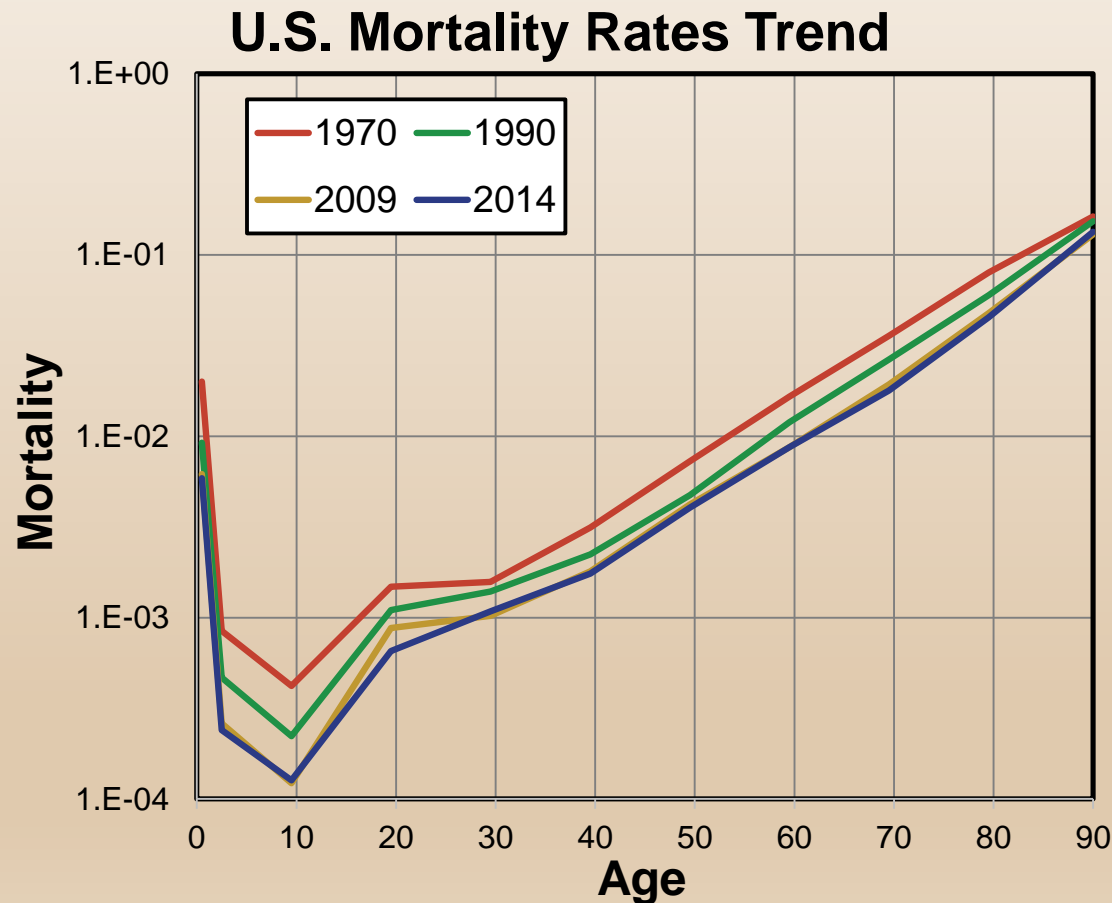
History



- APF > 1 in 10,000/year
- Whitman and Baecher (1981)
- Von Thun (1985) **1.4 E-04**
- Hatem (1985) **2.6E-04**
- M.K. Engineers (1988)
- Foster et al. (1998)
- Douglas et al. (1998)

Figure from Silva, F et al, "Probability and Risk of Slope Failure", *Journal of Geotechnical and Geoenvironmental Engineering*, Volume 134 Issue 12 – Dec 2008.

Background Risk



- Based on CDC information for all causes of death
- Chances of death from people living in an inundation zone is typically small
- The objective of the individual risk guideline is to ensure a particular structure does not significantly increase the overall mortality risk of an individual in the inundated area

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Definitions and Terminology

- **Risk** – The product of the likelihood of a structure being loaded, adverse structural performance, and the magnitude of the resulting consequences

(USBR terminology: “risk” refers to both probability of failure and annualized life loss)

- **Tolerable Risk** – A risk within a range that society can live with so as to secure the benefits provided by the dam or levee. It is a risk that is not to be regarded as negligible or ignored, but needs to be kept under review and reduced further if possible.

(USBR terminology: “Public Protection Guidelines”)



Individual Risk (Includes Probability of Failure)

- Individual Risk is represented by the probability of life loss for the identifiable person or group by location that is most at risk of loss of life due to dam or levee breach. Individual risk is the sum of the risks from all failure modes associated with the hazards that affect that person.
- If the person most at risk is assumed to be in harm's way all of the time and assured to perish if the dam or levee breaches, then the annualized failure probability is equivalent to individual risk.
- Guidelines established for either are meant to provide a level of protection even if the consequences are not high.



Societal Risk

- Societal risks are the probability and severity of adverse consequences from hazards that impact on society as a whole and create a socio-political response because multiple fatalities occur in one event. Society is increasingly averse to hazards as the scale of the consequences increase. This is commonly shown on an f-N or F-N diagram as a guideline with a negative slope.

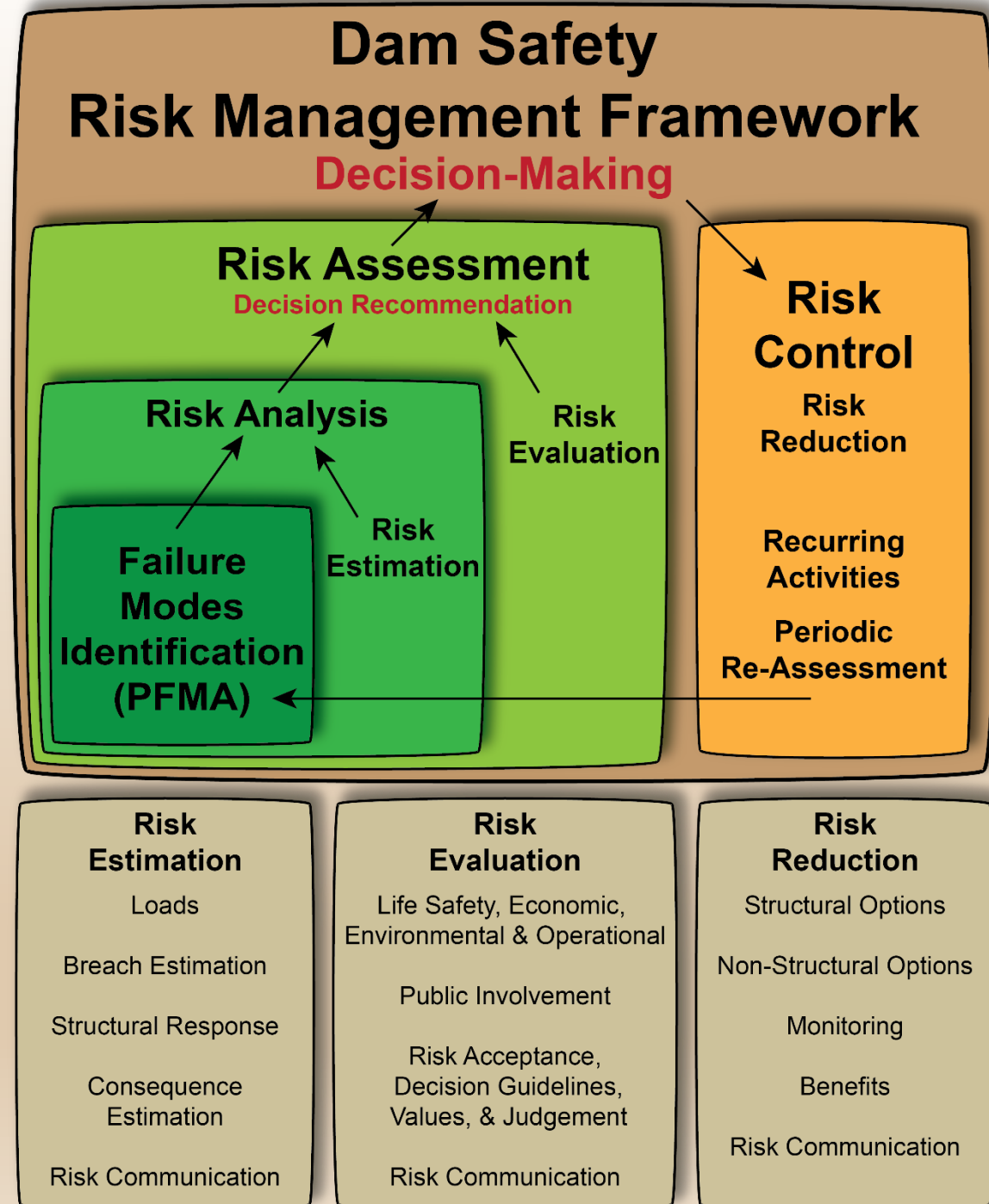


Dam and Levee Risk vs. Flood Risk

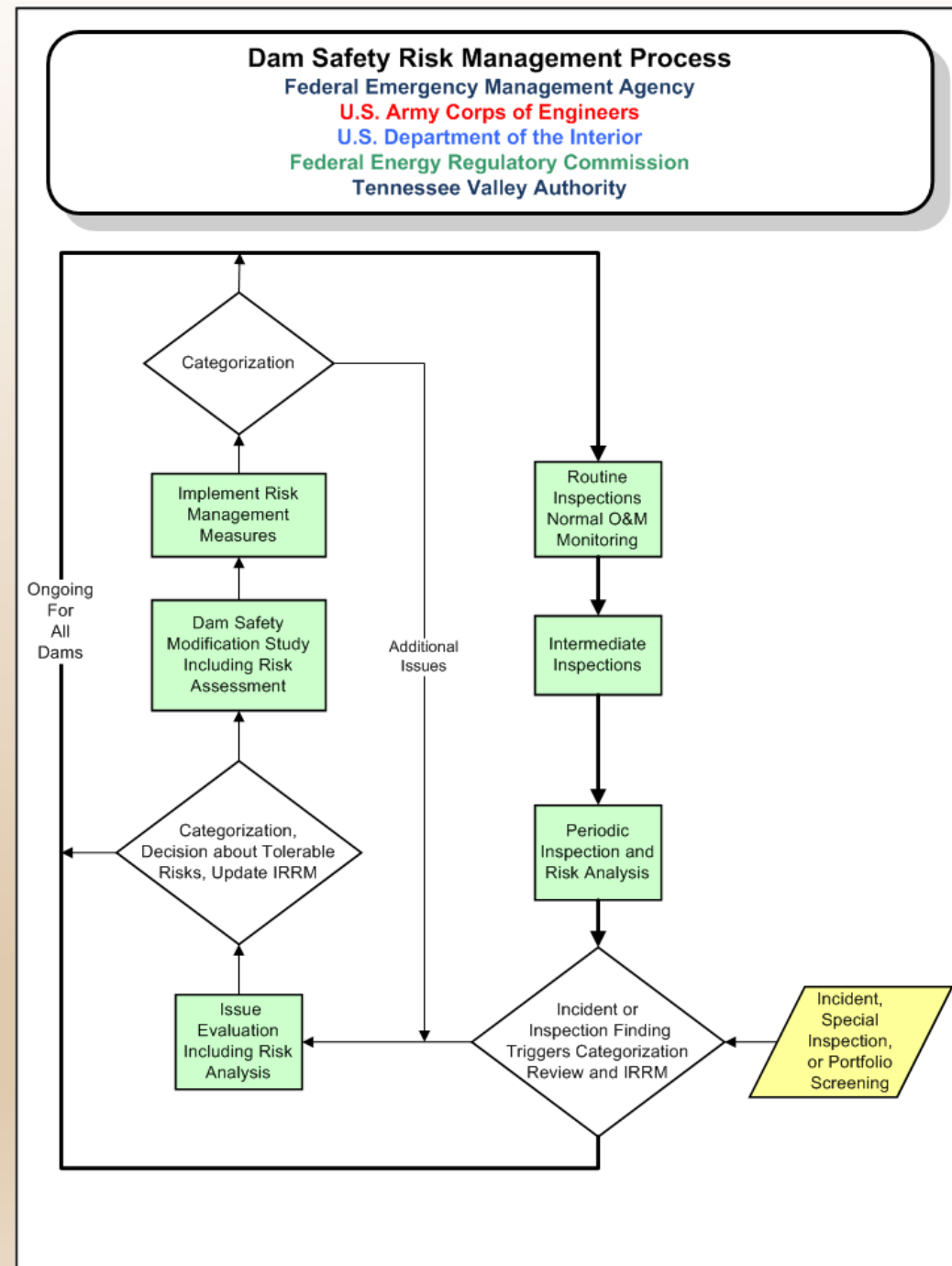
- **Dam/Levee Risk** – Risk posed by potential poor performance of dam or levee, also known as incremental risk associated with breach of dam or levee.
- **Flood Risk** – Includes dam/levee risk as well as risk of flooding from capacity exceedance of dam or levee (non-breach).
- Tolerable Risk Concepts and Decisions for Dam and Levee Safety are based on Dam/Levee Risk
 - Background risk is assumed to include that risk associated with proper performance of dam/levee



Risk Management Framework



Risk Management Process



Tolerable Risk Framework (USACE)

Efficiency - The need for society to distribute and use available resources to achieve the greatest benefit.

Equity - The right of individuals and society to be protected, and the right that the interests of all are treated with fairness.

Disproportionality - Disproportionality measures the ratio of the annualized costs to implement a risk reduction measure versus the annualized risk cost without the risk reduction measure.

Increasing Risks and Societal Concerns

Unacceptable

Risk cannot be justified except in extraordinary circumstances

1 / 10,000

Range of Tolerability

People and Society are prepared to accept risk in order to secure benefits

ALARP

1 / 1,000,000 ?

Broadly Acceptable

Risk regarded as insignificant and adequately controlled

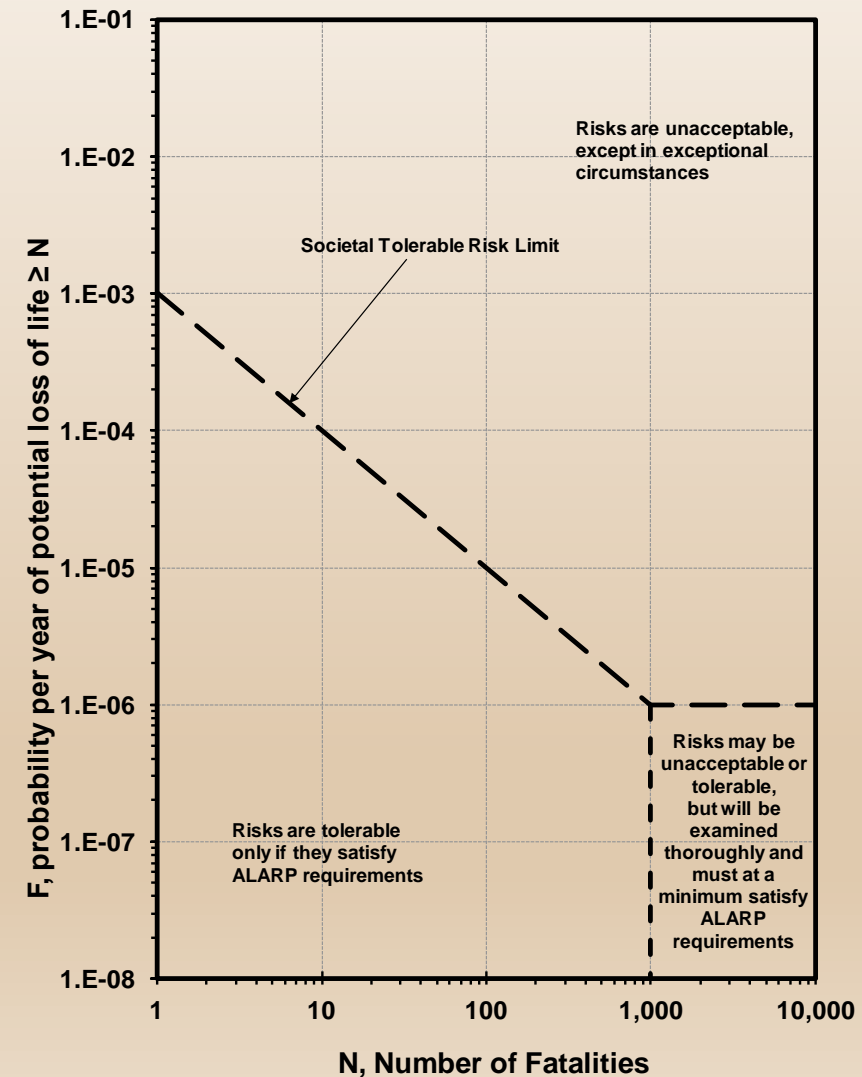
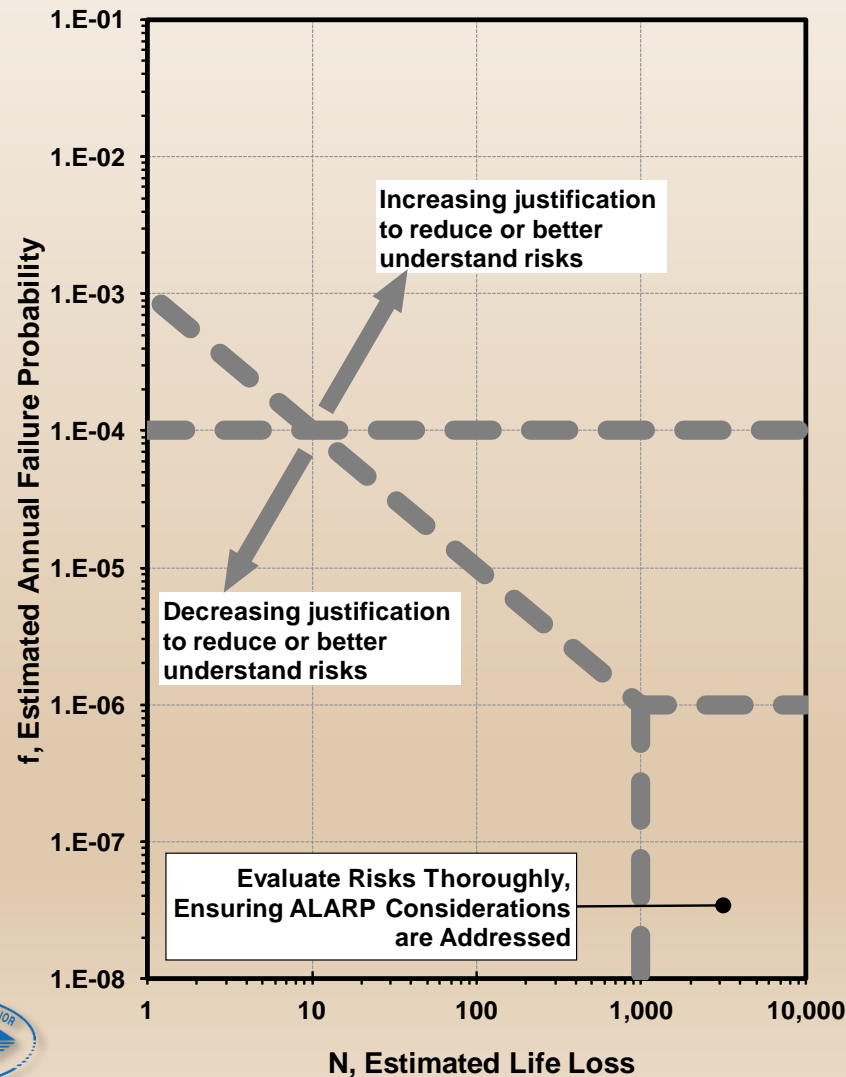


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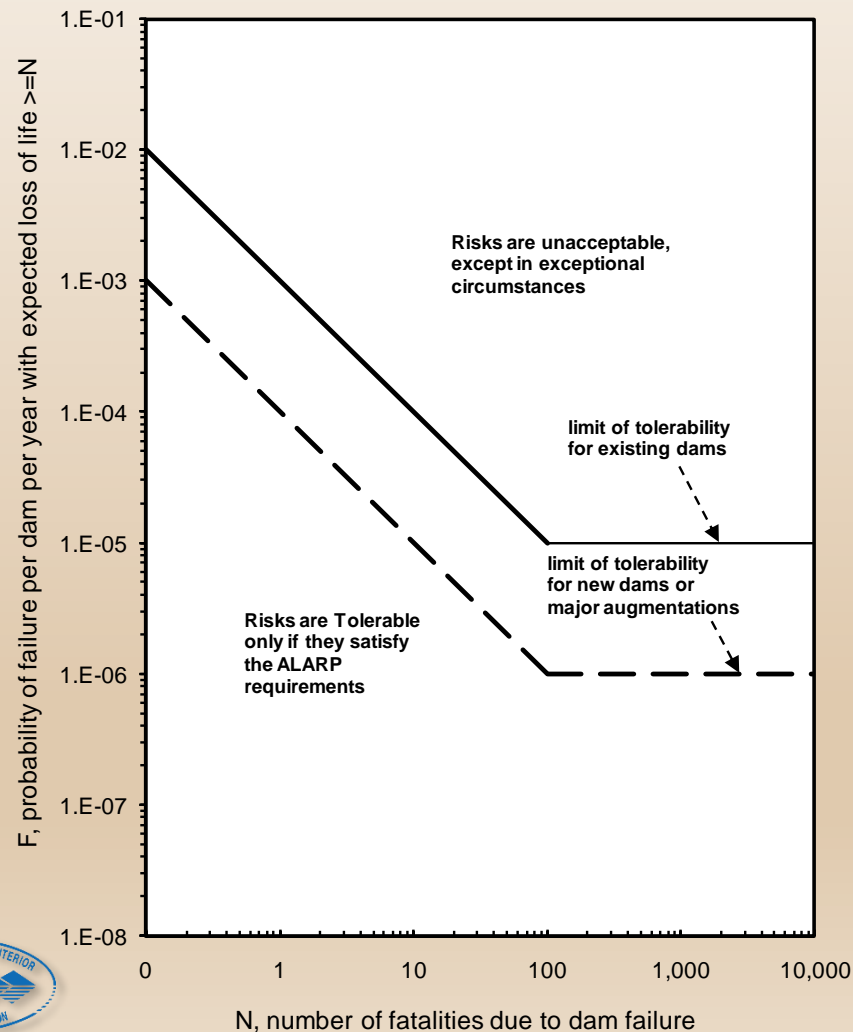
USACE Tolerable Risk Guidelines

USBR Public Protection Guidelines

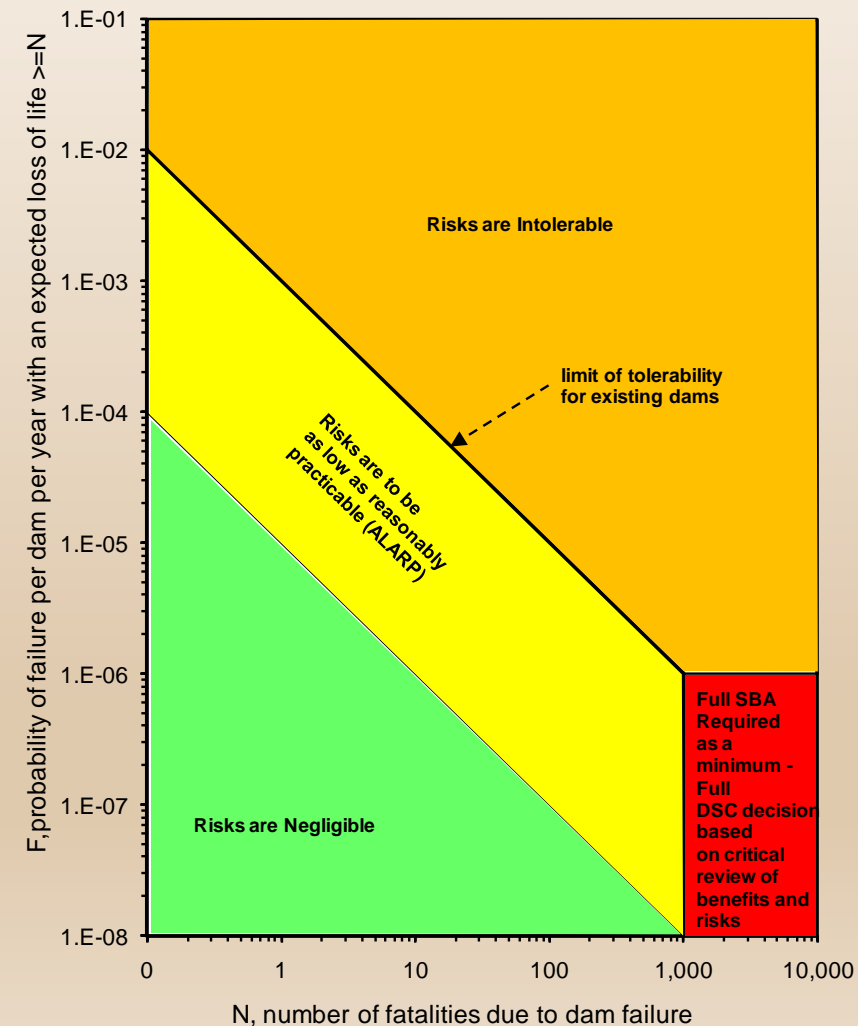


Tolerable Risk Guidelines

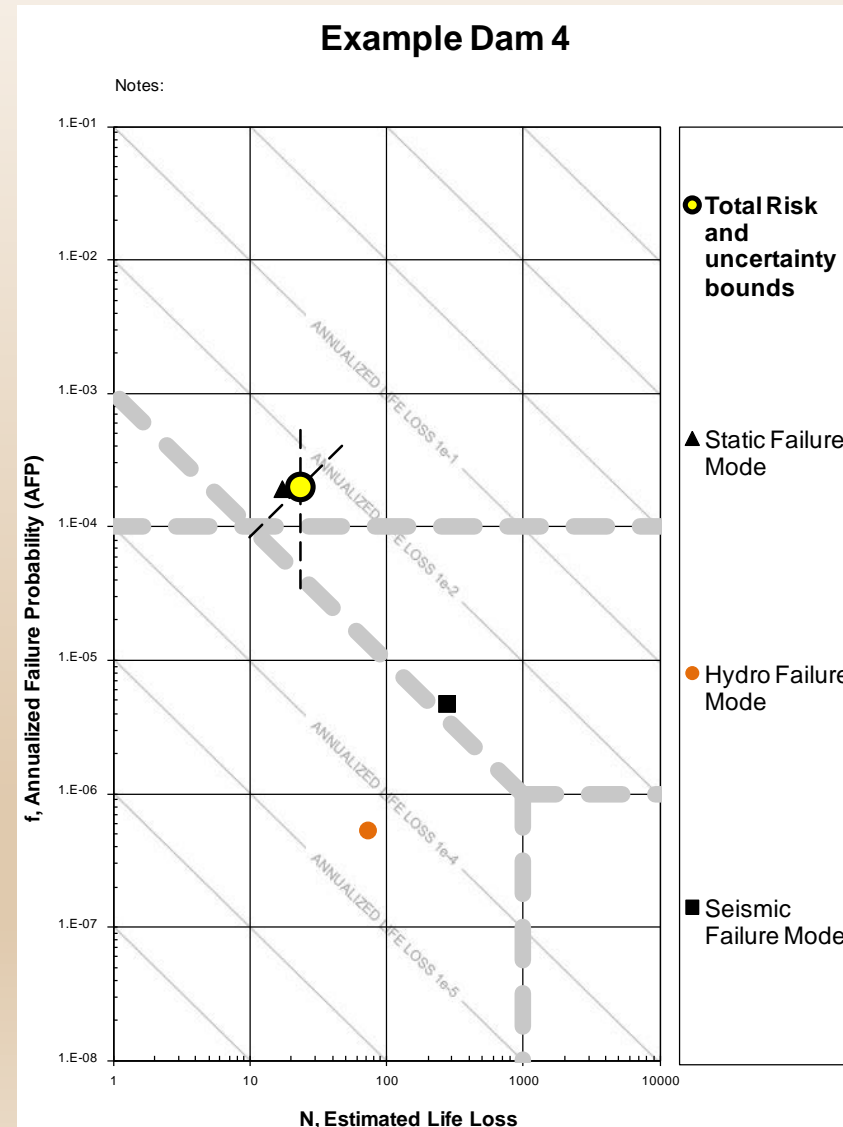
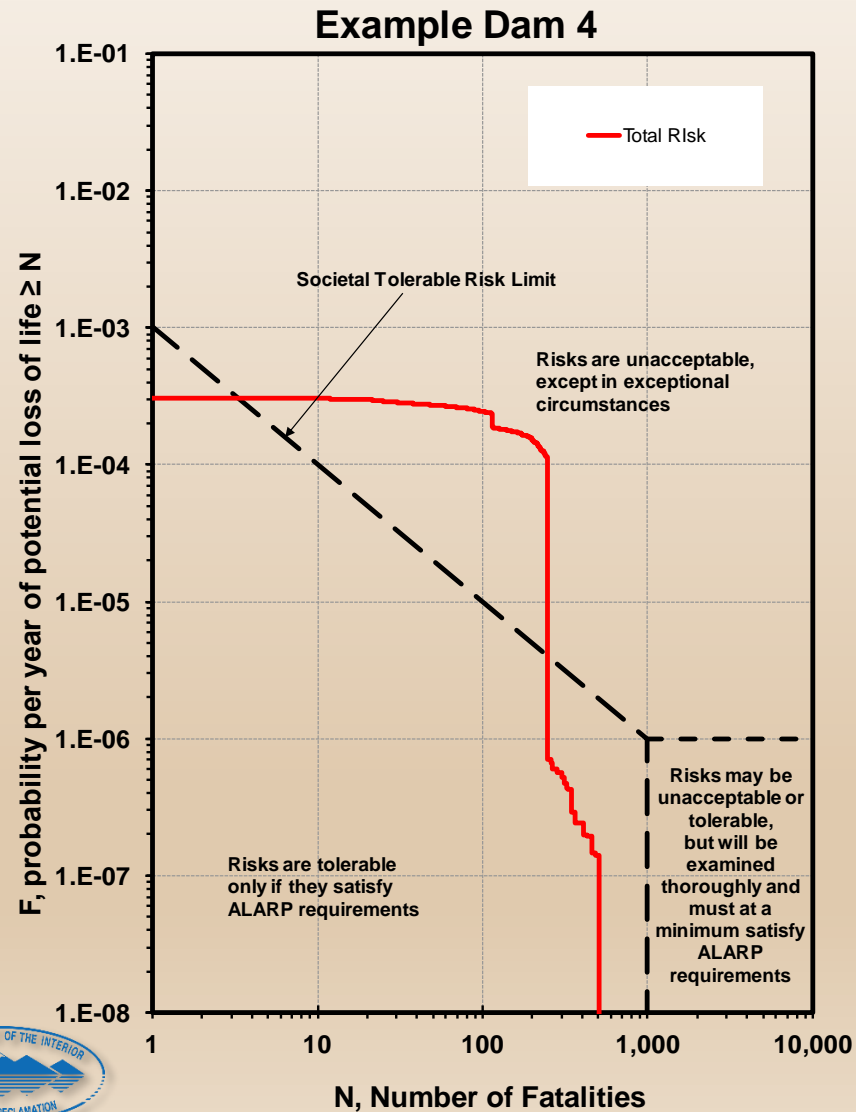
Revised ANCOLD Societal Risk Reference Guideline



Proposed Societal Risk Requirements: Existing Dams

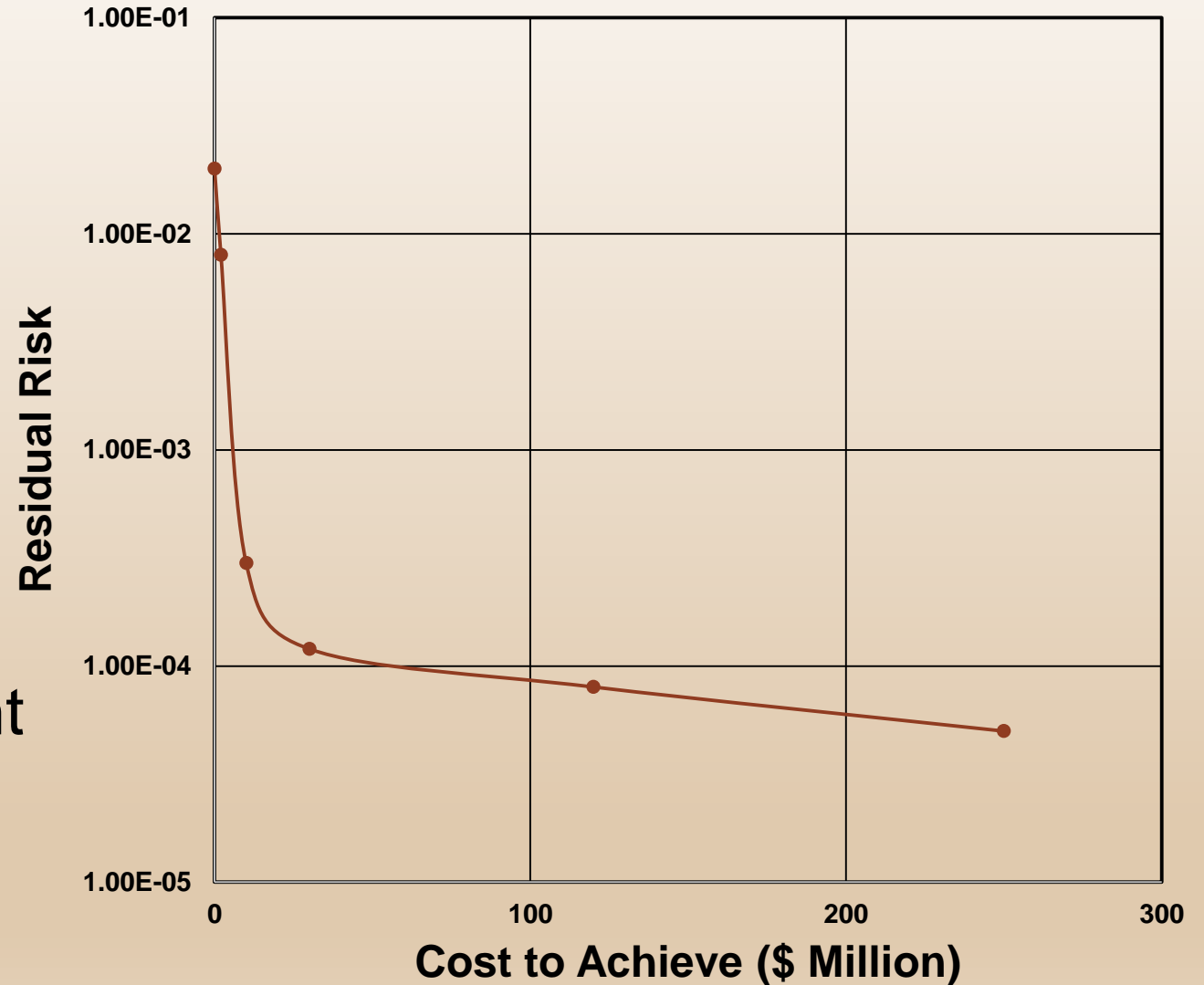


F-N and f-N Charts



ALARP

- ALARP is a balance between risk reduction and cost
- Reasonable and prudent low cost action: build the case without complex numerical evaluation
- A rigorous evaluation of disproportionality can be performed
- A more qualitative assessment can be considered whereby break points related to diminishing returns are identified



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Urgency – Joint Federal Risk Categories Table

Urgency of Action	Characteristics and Considerations	Potential Actions
I - VERY HIGH URGENCY	<p>CRITICALLY NEAR FAILURE: There is direct evidence that failure is in progress, and the dam is almost certain to fail during normal operations if action is not taken quickly.</p> <p>OR</p> <p>EXTREMELY HIGH RISK: Combination of life or economic consequences and likelihood of failure is very high with high confidence.</p>	<ul style="list-style-type: none"> Take immediate action to avoid failure. Communicate findings to potentially affected parties. Implement interim risk reduction measures. Ensure that the emergency action plan is current and functionally tested. Conduct heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. Initiate intensive management and situation reports.
II - HIGH URGENCY	RISK IS HIGH WITH HIGH CONFIDENCE, OR IT IS VERY HIGH WITH LOW TO MODERATE CONFIDENCE: The likelihood of failure from one of these occurrences, prior to taking some action, is too high to delay action.	<ul style="list-style-type: none"> Implement interim risk reduction measures. Ensure that the emergency action plan is current and functionally tested. Give high priority to heightened monitoring and evaluation. Expedite investigations and actions to support long-term risk reduction. Expedite confirmation of classification.
III - MODERATE URGENCY	MODERATE TO HIGH RISK: Confidence in the risk estimates is generally at least moderate, but can include facilities with low confidence if there is a reasonable chance that risk estimates will be confirmed or potentially increase with further study.	<ul style="list-style-type: none"> Implement interim risk reduction measures. Ensure that the emergency action plan is current and functionally tested. Conduct heightened monitoring and evaluation. Prioritize investigations and actions to support long-term risk reduction. Prioritize confirmation of classification as appropriate.
IV – LOW TO MODERATE URGENCY	LOW TO MODERATE RISK: The risks are low to moderate, and confidence in the risk estimates is low with the potential for the classification to move higher, with further study.	<ul style="list-style-type: none"> Ensure that routine risk management measures are in place. Determine whether action can wait until after the next periodic review. Before the next periodic review, take appropriate interim measures, and schedule other actions as appropriate. Give normal priority to investigations to validate classification, but do not plan for risk reduction measures at this time.
V – NO URGENCY	LOW RISK: The risks are low and are unlikely to change with additional investigations or studies.	<ul style="list-style-type: none"> Continue routine dam safety risk management activities and normal operations and maintenance.



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